Development and Testing of a Rotary Percussive Sample Acquisition Tool

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Test Configuration

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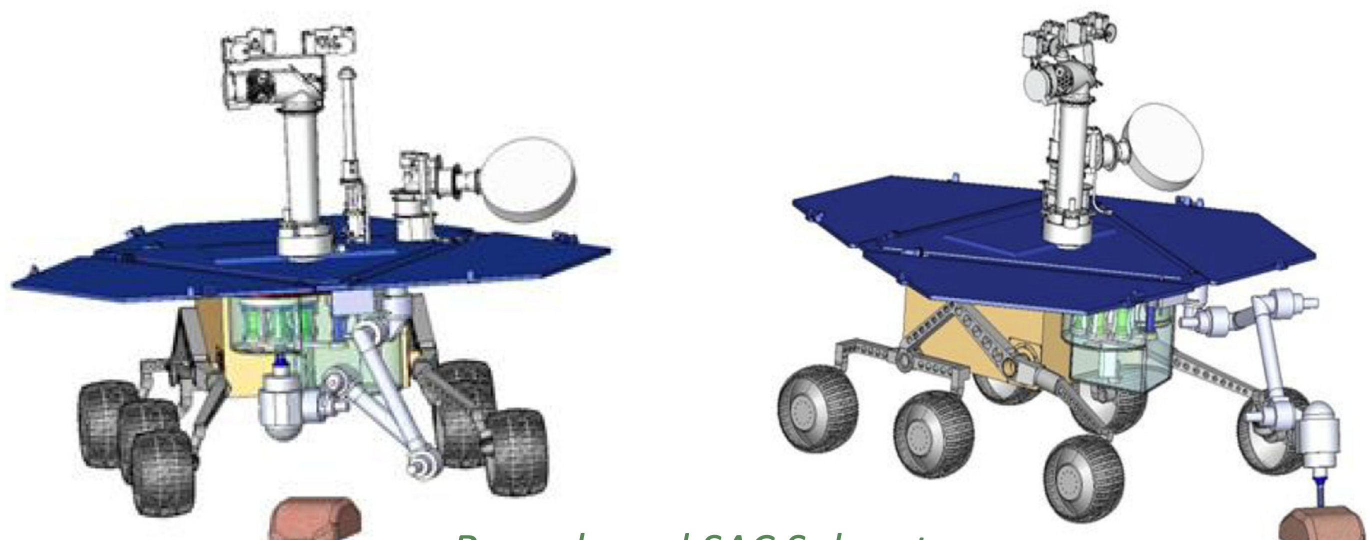
Hardware Durability

Conclusion

The work was performed as part of a potential Mars Sample Return (MSR) campaign

It is foreseen that a **Sample Acquisition and Caching (SAC)** subsystem would be necessary for acquiring and storing samples



Rover based SAC Subsystem

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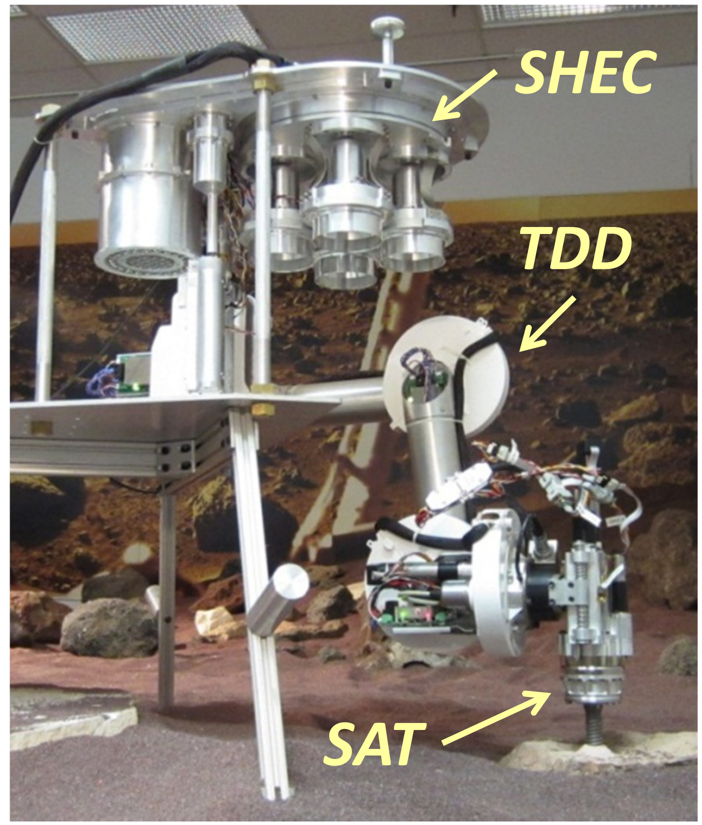
Integrated Mars Sample Acquisition and Handling (IMSAH) architecture has been proposed to satisfy SAC subsystem needs

Three main sub-elements:

1) Tool Deployment Device (TDD)
2) Sample Handling Encapsulation and Containerization (SHEC)
3) Sample Acquisition Tool (SAT)



IMSAH Hardware

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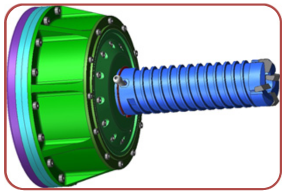
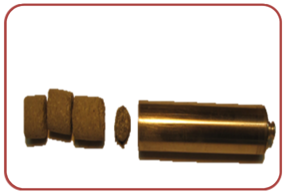
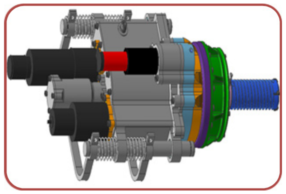
Key enabling **IMSAH** elements that allow for autonomous coring and caching:



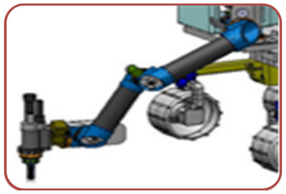
bit change-out for sample transfer



Core directly into individual sample tubes



Rotary Percussive Coring Tool (SAT) allows for reduced tool preload



5-DOF Robotic Arm (TDD) with force feedback

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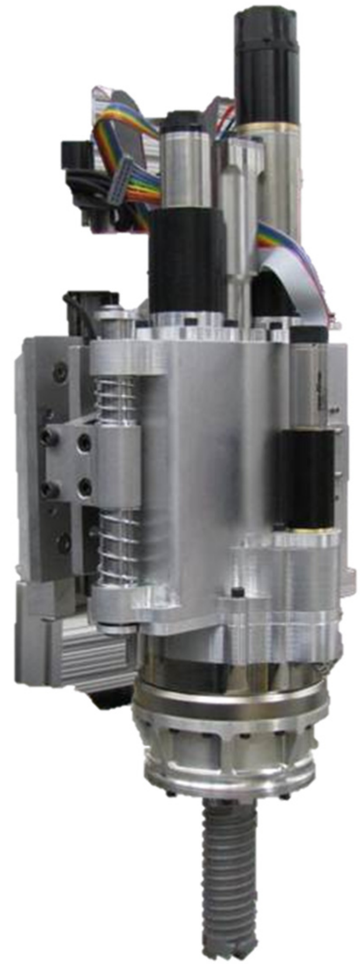
The **Sample Acquisition Tool (SAT)** is designed for autonomous:

- coring
- core fracture/retention
- bit change-out



SAT is a less complex coring tool than what has previously been proposed:

- TDD can be used for tool feed
- Reduced tool preload

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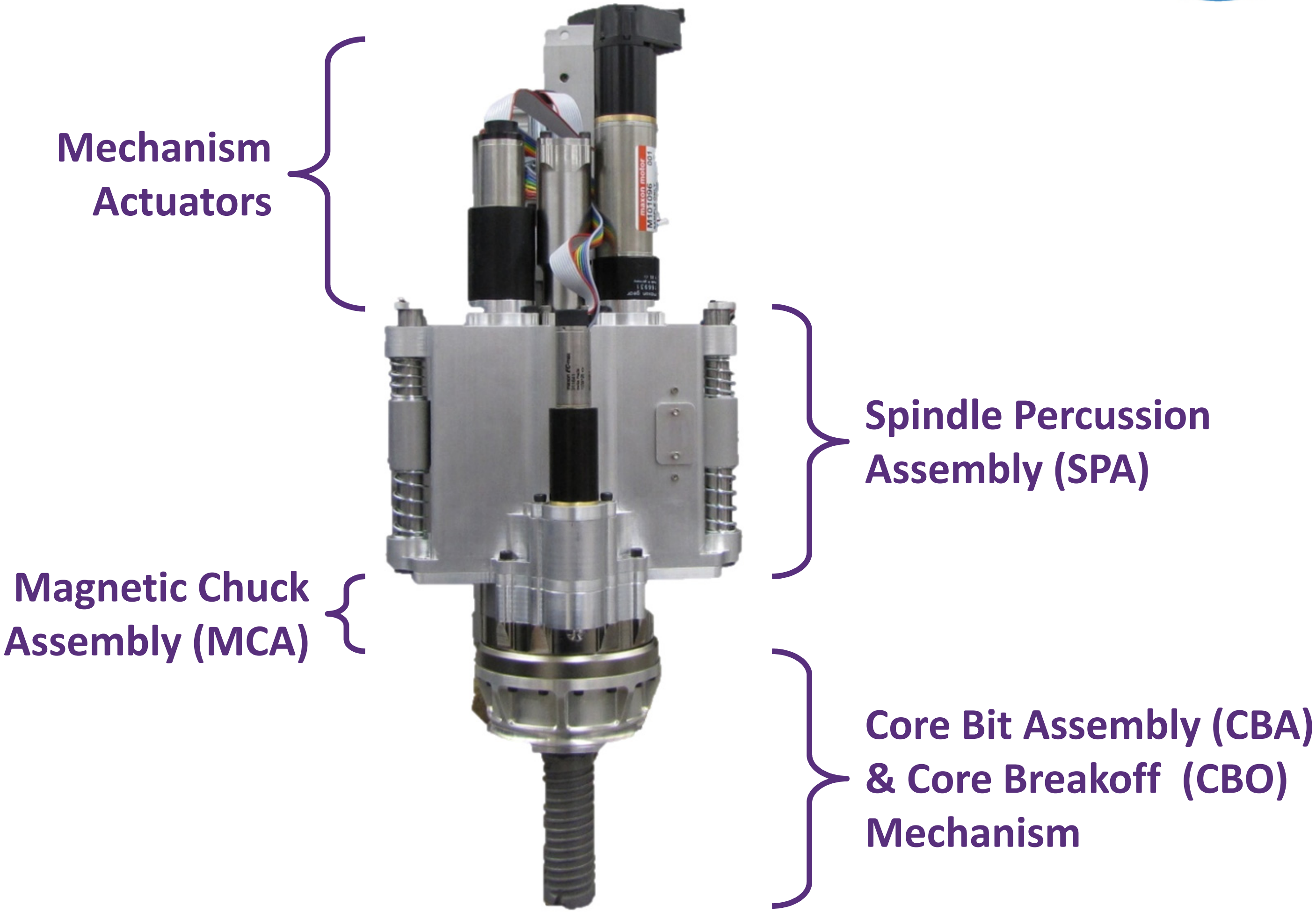
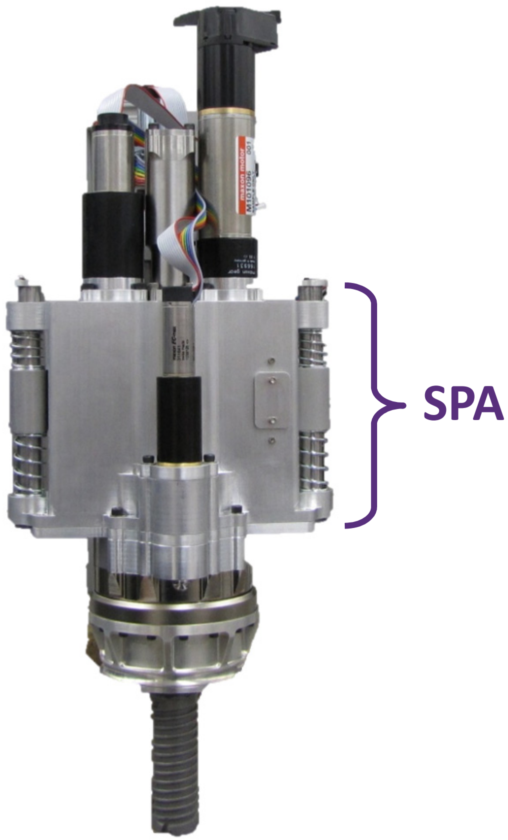
The **SAT** is comprised of four main subassemblies

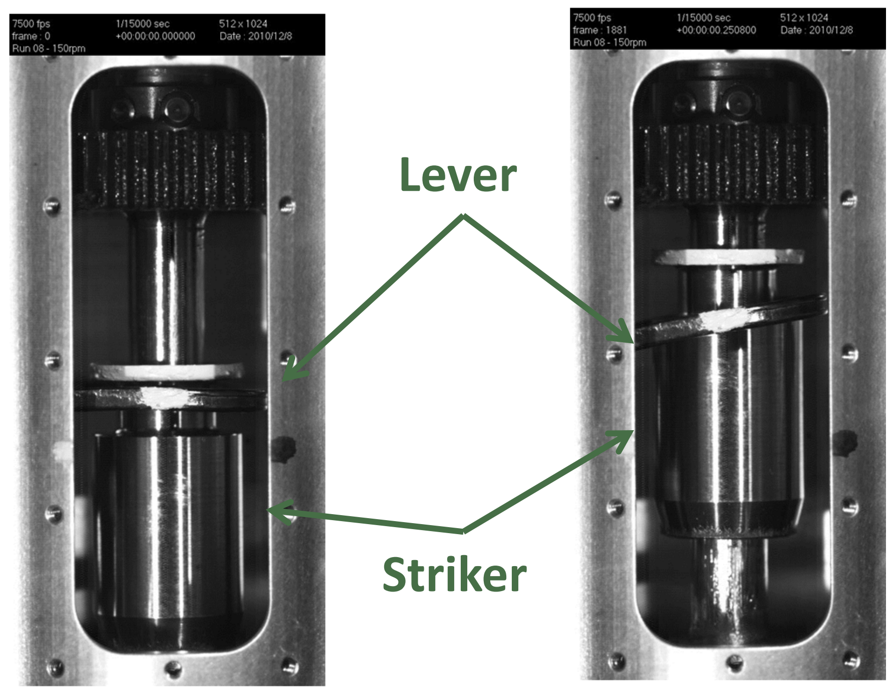


The **Spindle Percussion Assembly (SPA)** provides:

- rotational DOF to drive the CBA
- axial motion to drive the percussion striker mass



Percussion striker shown thru full range of motion



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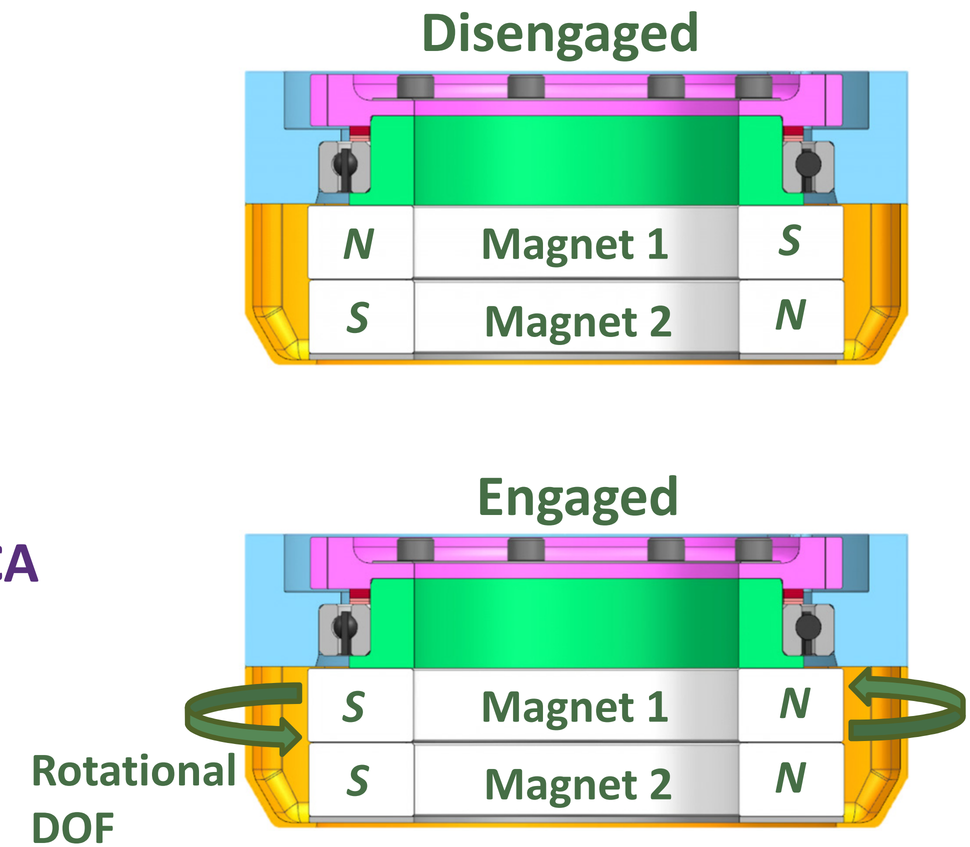
The **Magnetic Chuck Assembly (MCA)** utilizes two diametrically polarized permanent magnets

- Passive release of CBA under predefined side and/or axial loads



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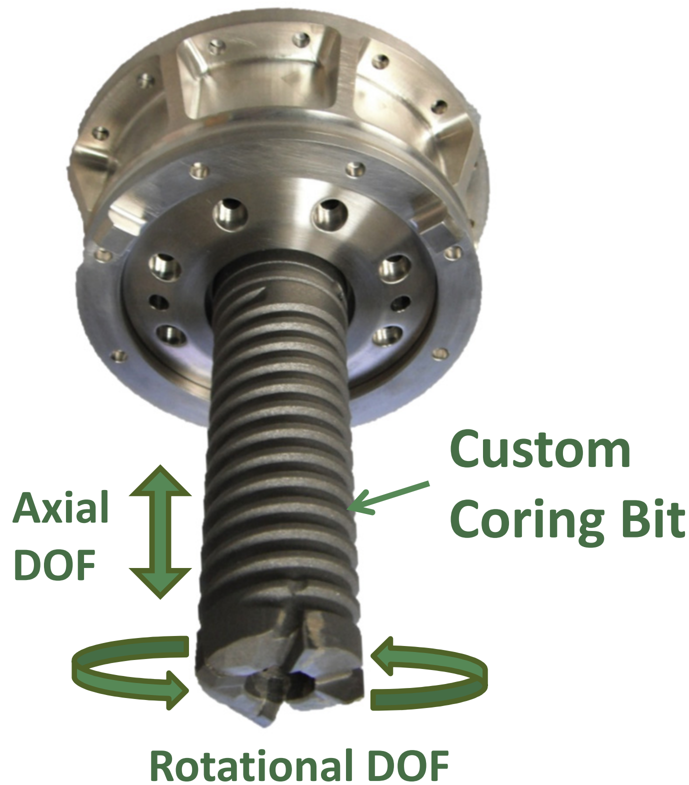
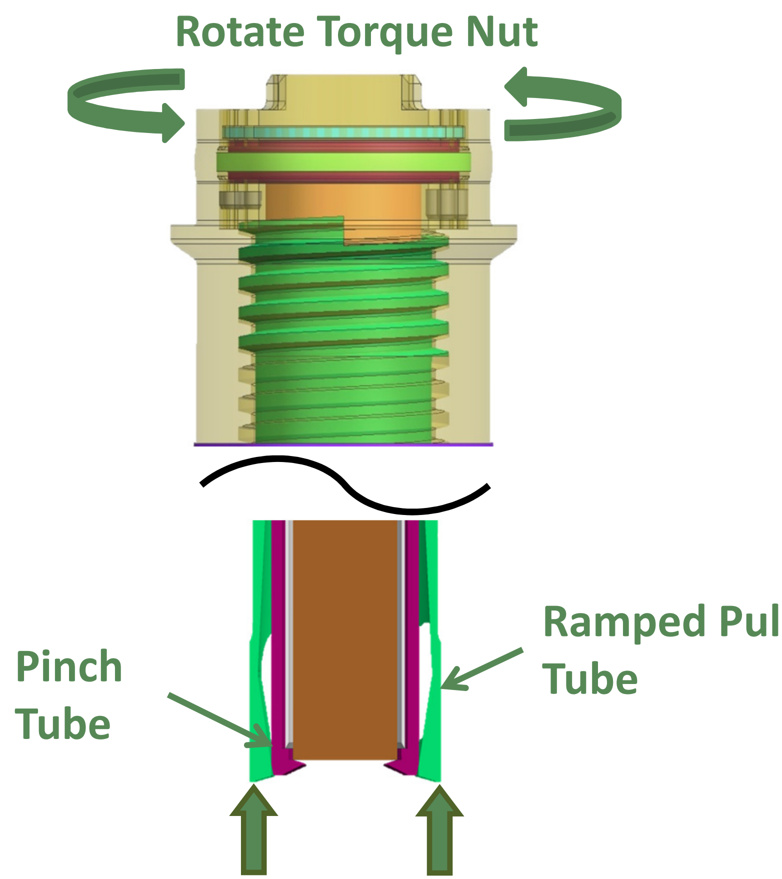
The **Core Bit Assembly (CBA)** uses a custom coring bit that functionally:

- allows engagement with the magnetic chuck
- accepts the rotational DOF from the SPA
- allows for an axial DOF for maximum transmission of impact energy



The **Core Breakoff (CBO)** mechanism uses a cleaving approach for core fracture

- allows for a well-controlled and predictable fracture plane



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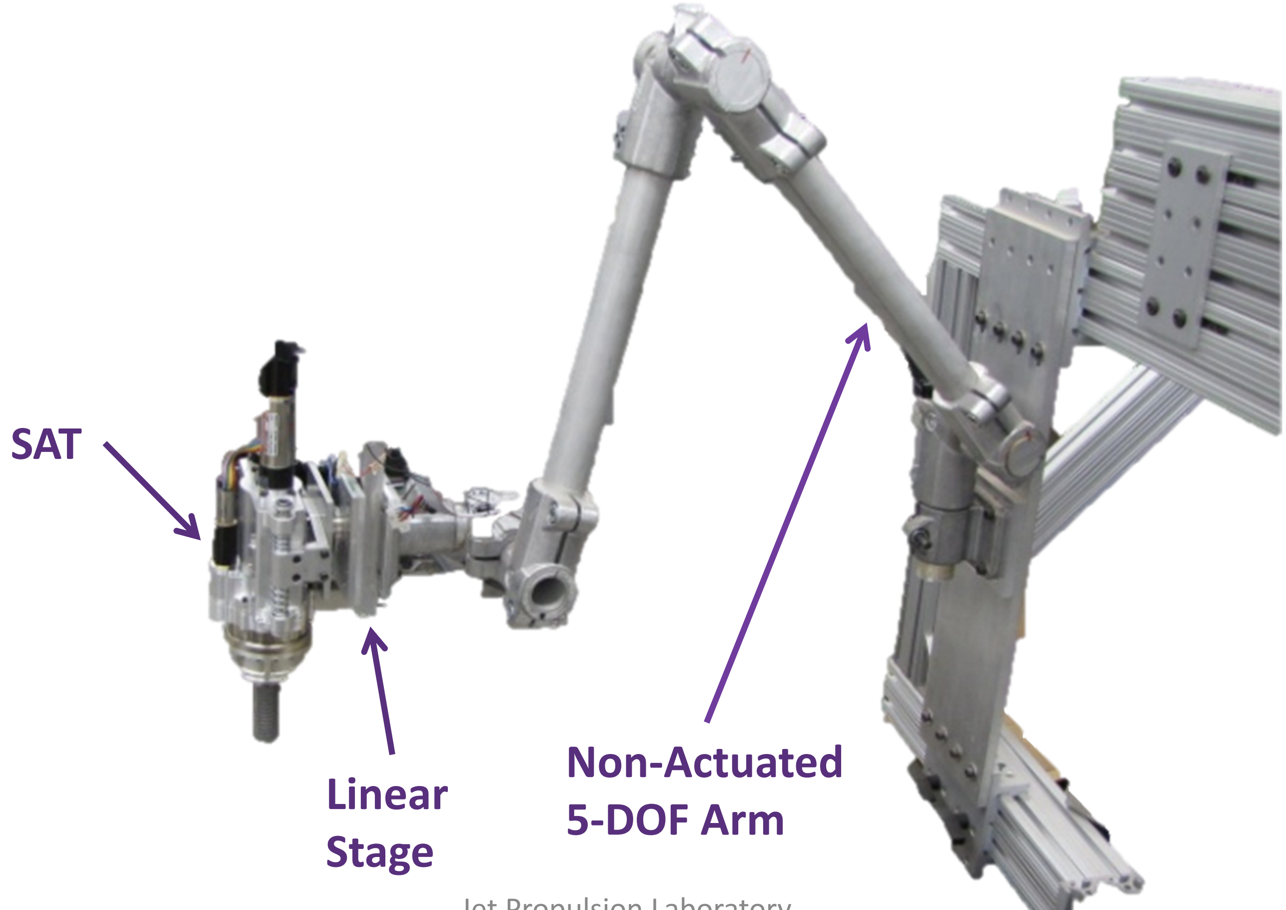
SAT assembly level test configuration

- Surrogate arm allowed for realistic boundary conditions
- No arm force feedback
- Used a linear stage for linear feed
- Used a force sensor for controlling weight on bit



Tool verification performed using **analogous Martian rock test suite**

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End-to-end unit level testing: core generation, fracture, and capture

Kaolinite

- Intact cores

Limestone

- Mostly intact cores

Siltstone

- Segmented disks

SB Basalt

- Mostly intact cores

V. Breccia

- Mostly intact cores

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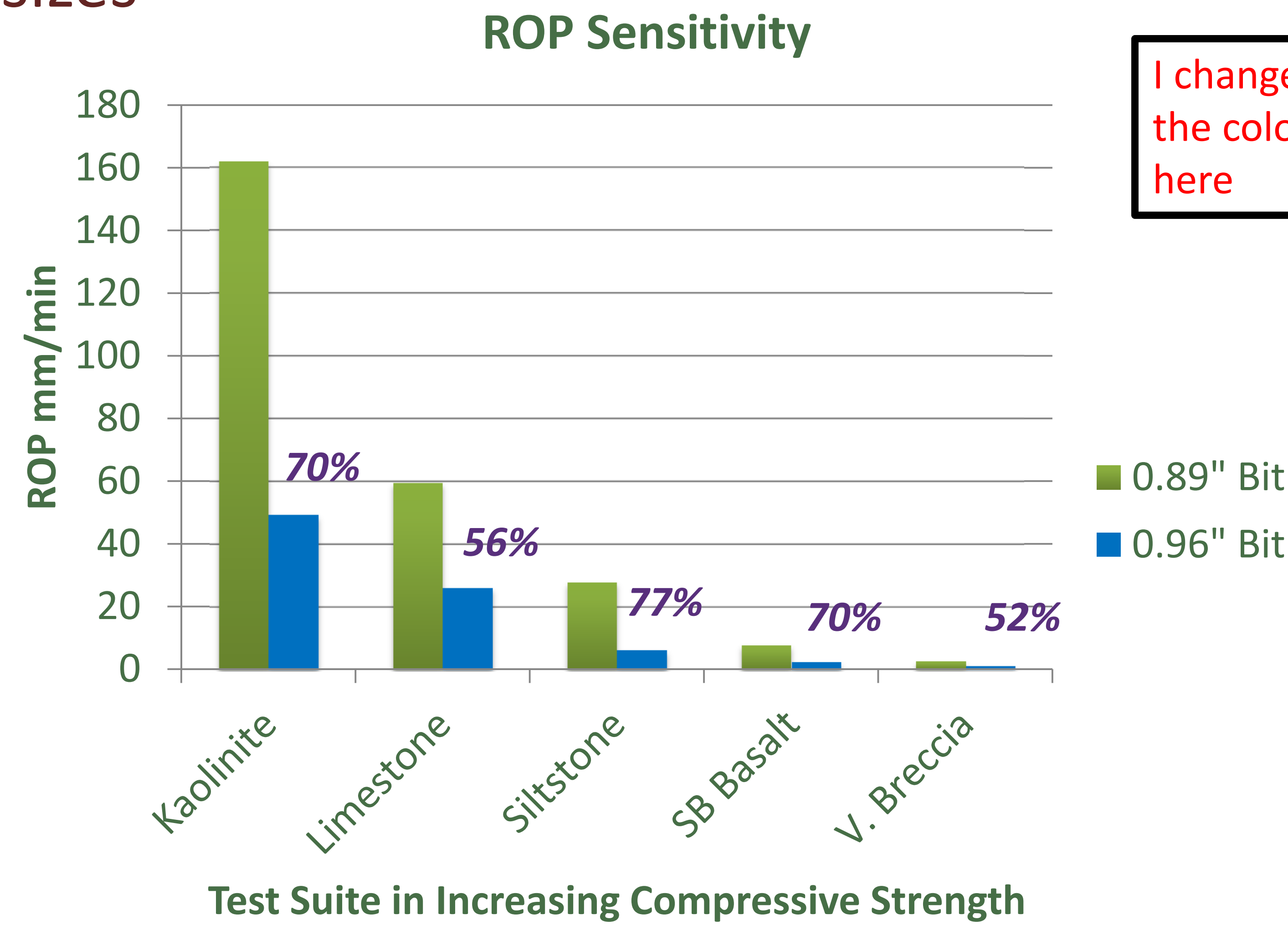
SAT tool **Rate of Penetration (ROP)** sensitivity investigated against two bit sizes



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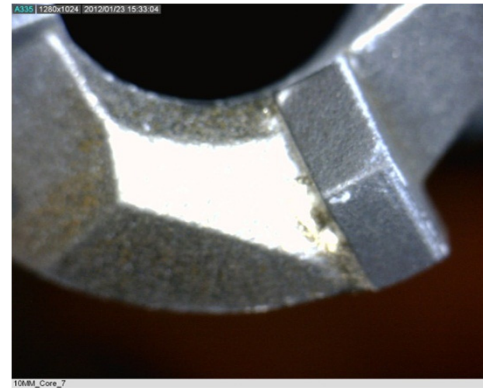
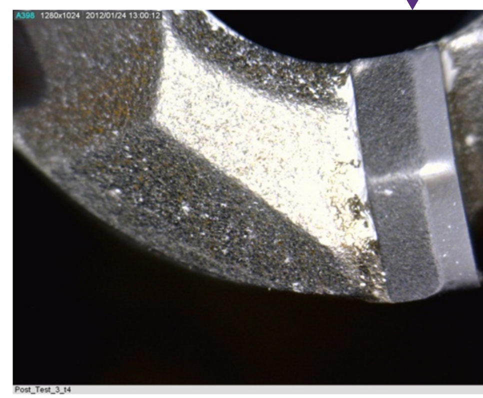
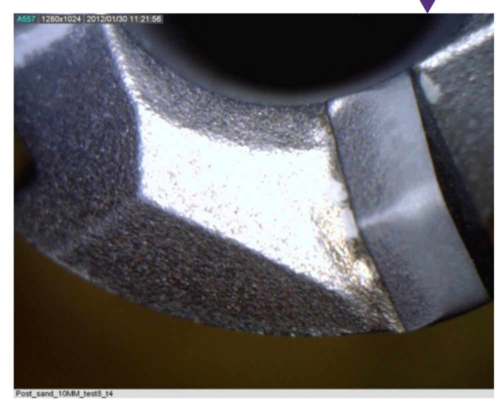
Bit wear observed due to several factors:

- Tool is operated at minimum percussion levels required to drill rocks
- Bits designed for percussive drilling do not handle abrasive rocks well at low percussion levels (rotary drilling vs. percussive drilling)

Use of rotary grade Tungsten Carbide did little to reduce bit wear







Successfully demonstrated a low mass coring tool for autonomous core generation, fracture, and capture

Several key tool features identified worth further investigation

- Core quality concerns
- Bit lifetime
- De-coupling of the Spindle and Percussion Mechanisms
- Increased percussion capability

Questions?